BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a schematic showing an illustrative embodiment of the invention.

[0014] **FIG. 2** is a modification to the system of **FIG. 1** showing an alternative coupling arrangement for the LF power supply.

[0015] **FIG. 3** shows, in schematic form, an arrangement for using the plasma source of the present invention with a roll of film.

[0016] **FIG. 4** is an example of an electrode arrangement that can be used in a tri-phase powering arrangement.

[0017] **FIG. 5** shows a typical arrangement for the phase differences between three supplies for use with the electrode arrangement of **FIG. 4**.

[0018] **FIG. 6** shows an alternative pumping arrangement for introducing and pumping of gas in the plasma chamber according to the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] **FIG. 1** shows a schematic of operational components of a plasma source **100** in accordance with an embodiment of the present invention. The source **100** includes a plasma excitation region **110**, into which a process gas may be introduced. This region defines the ultimate plasma volume and it is within this region that the gas is converted into a plasma, which is then used to process workpieces placed within the region. A plasma exciting reactive impendence element **105** is provided above the excitation region **110**. This element is coupled to a high frequency (HF) generator or source **125**, the application of which to the element being used to control density of the plasma. Within the present description the term high frequency is intended to encompass electromagnetic radiation provided in the range 30 kHz-300 GHz, which sometimes would be referred to as frequency in the radio-frequency to ultra-high frequency range. A reference electrode **115** is displaced below the region **110** and is optionally coupled to a low frequency (LF) source, the application of which is used to control the energy of the ions striking the surface (as per present state-of-the-art). The reference electrode provides a mount for the workpiece (not shown), which is typically a semiconductor, dielectric or metal substrate. The application of suitable fields to the elements **105**, **115** serves to generate and maintain the correct ratio of ions and radicals relative to neutral species in the plasma and a control of the energy of the ions incident on the workpiece; gas transport and the residence time of these particles in the excitation region play an important role. This control is required to ensure a correct methodology for the selected deposition or etch processes being employed.

[0020] In accordance with the present invention, the reactive element is fabricated from a plurality of individual electrodes, shown in this example as four electrodes **105***a*, **105***b*, **105***c*, **105***d*, the four electrodes combining to form two sets of electrodes **105***a*/**105***c* and **105***b*/**105***d*. Desirably, an even number of electrodes are provided and each of the electrodes is individually coupled to the high frequency power supply which is configured to provide a differential signal to adjacent electrodes. In this manner the signal applied to a first electrode **105***a* is out of phase with the signal applied to its immediate neighbour **105***b*. Similarly electrode **105***b* is out of phase with electrode **105***c* and electrode **105***c* is out of phase with electrode **105***d*. In this way it can be considered that the high frequency generator or drive creates a differential between sets of electrodes. By the very nature of inductive coupling, wavelength effects will be present in the electrodes and the plasma but the multiple electrodes that make up the reactive element of the present invention are advantageous in that the wavelengths effects can be controlled so as to yield the desired plasma density as opposed to the traditional single electrode problem of non-uniform effects. The dimensions of the individual electrodes are chosen and optimized such that non-uniformities on the scale-length of the electrode size that occur adjacent to the reactive elements do not result in excessive plasma non-uniformity at the substrate. It will be appreciated that these dimensions may vary depending on the specific application for which the plasma source is used but desirably the size of each of the individual electrodes is less than or equal to the distance between the source and the substrate or workpiece and is such as to provide uniform effects, if so desired for the particular application. A transformer **111** may optionally also be included if there is a requirement for the equalisation of currents.

[0021] **FIG. 2** shows a plasma source **200** which is a modification to the arrangement of **FIG. 1** where both the LF and HF supplies are coupled to the reactive element. In this embodiment, the HF generator and the LF generator may be applied simultaneously or independently of one another. By coupling both generators to the same reactive element plate it is possible for the lower electrode, the reference electrode, to be grounded. It is not necessary to provide a capacitor in this path to ground (i.e. the reference electrode can be directly coupled to ground), and this arrangement of enabling the reference electrode to be grounded is highly advantageous in that the engineering requirements for the chamber are simplified. For example, in arrangements where a moveable bottom stage was provided it was traditionally necessary for the bellows that make up that moveable stage to define an unknown and variable impedance path; with the grounding of this lower stage, this is no longer a requirement. It will be appreciated that using techniques known in the art that the effect of the LF output can be maximised in the region of interest by confining the plasma volume. This can be achieved in a variety of ways such as for example quartz confinement rings.

[0022] The LF supply can be provided in either a differential or a common mode. In a differential mode, with the low frequency signal applied to a first electrode being out of phase with that provided to its immediate neighbour, the ion energy is provided on the reactive element electrodes or on a dielectric material coupled thereto. If the LF supply is provided in a common mode, then greater ion energy is provided on the reference electrode. This driving of the plurality of electrodes making up the reactive element in a common mode configuration therefore controls the ion bombardment onto the workpiece that is mounted on the reference electrode. It will be understood that differential mode results in lower ion energy to the substrate (reference electrode) but maintains high ion energy to reactive elements for sputtering material and/or keeping electrodes clean from deposition. Similarly to that described with reference to **FIG. 1**, a transformer **112** may optionally be provided for coupling LF either in common mode or differ-